UDC 621. 391. 823

BBC

RESEARCH DEPARTMENT

1969
THE QUEEN'S AWARD
TO INDUSTRY

REPORT

UHF TELEVISION: the interference caused by a receiver operating on channel n to an adjacent receiver tuned to channel n+4

No. 1970/9

Research Department, Engineering Division
THE BRITISH BROADCASTING CORPORATION

RESEARCH DEPARTMENT

UHF TELEVISION: THE INTERFERENCE CAUSED BY A RECEIVER OPERATING ON CHANNEL n TO AN ADJACENT RECEIVER TUNED TO CHANNEL n + 4

Research Department Report No. **1970/9**
UDC 621.391.823

This Report may not be reproduced in any form without the written permission of the British Broadcasting Corporation.

It uses SI units in accordance with B.S. document PD 5686.

Work covered by this report was undertaken by the BBC Research Department for the BBC and the ITA

D. Maurice

J.G. Spencer

Head of Research Department

(RA-57)

Research Department Report No. 1970/9

UHF TELEVISION: THE INTERFERENCE CAUSED BY A RECEIVER OPERATING ON CHANNEL n TO AN ADJACENT RECEIVER TUNED TO CHANNEL n + 4

Section Title Page

SUMMARY 1

1. INTRODUCTION 1

2. RECEIVING INSTALLATIONS AND B.S. LIMITS 1

2.1. Coupling between Aerials of Adjacent Installations 1
2.2. Direct Radiation from Interfering Receiver 1
2.3. Receiving Aerial and Feeder Installation 1
2.4. B.S.905:1969 Limit for R.F. Voltages appearing at the Receiver Aerial Terminals 2
2.5. B.S.905:1969 Limit on Local-Oscillator Radiation 2
2.6. B.S.905:1969 Limit on Immunity 2

3. SIGNAL-TO-INTERFERENCE RATIOS 2

3.1. Interference arising from Aerial-to-aerial Coupling 2
3.2. Interference arising from direct Receiver-to-receiver Coupling 2

4. PROTECTION RATIO REQUIRED AGAINST C.W. INTERFERENCE 3

5. DISCUSSION 3

6. CONCLUSIONS 4

7. REFERENCES 4

(RA-57)

March 1970.

Research Department Report No. **1970/9**
UDC 621.391.823

UHF TELEVISION: THE INTERFERENCE CAUSED BY A RECEIVER OPERATING ON CHANNEL n TO AN ADJACENT RECEIVER TUNED TO CHANNEL n + 4

SUMMARY

The interference that a television receiver tuned to a u.h.f. channel n can cause to a neighbouring receiver tuned to channel n + 4 was considered in the early stages of development of the u.h.f. plan.[1] *It then appeared that this type of interference could constitute a serious impairment of the quality of a colour television service at u.h.f. Since that time, British Standard 905, covering interference limits for u.h.f. and v.h.f. receivers, has been revised and this report re-examines the situation in the light of the revised limits.*

It is concluded that n to n + 4 interference will not present a serious problem if all receivers comply with the provisions of B.S.905/1969, in regard to the oscillator voltage at the aerial terminal, the direct oscillator radiation and the sensitivity to u.h.f. signals entering the receiver by routes other than the aerial terminal.

1. INTRODUCTION

This report is concerned only with the type of interference that a television receiver tuned to a u.h.f. channel n can cause to an adjacent receiver tuned to channel n + 4. The local-oscillator frequency of a receiver employing the U.K. standard vision carrier intermediate frequency (i.f.) of 39·5 MHz and accurately tuned to channel n will lie 7·5 MHz above the vision carrier frequency of channel n + 4. If the receiver on channel n is mistuned in a downwards direction by 1·5 MHz or more, interference to a receiver on channel n + 4 may result from pick-up of a signal at the local oscillator frequency.

This type of interference was discussed in a BBC Research Report issued in 1964[1]. Since that date the British Standard, B.S.905, dealing with interference limits for receivers, has been revised.[2] The BBC Report pointed out that two interference paths are important and require separate examination, namely radiation from the aerial affecting an adjacent aerial and direct chassis radiation affecting a nearby receiver through stray pick-up. The new British Standard requirements were framed on this basis and in the following text the problem is reviewed in the light of the new limits.

In order to calculate the effects of this form of interference it is necessary to make certain assumptions regarding receiving installations. These assumptions, together with the limits laid down in B.S.905: 1969 for the relevant parameters of receiver performance are set out below.

2. RECEIVING INSTALLATIONS AND B.S. LIMITS

2.1. Coupling between Aerials of Adjacent Installations

The ratio between the r.f. interference voltage appearing at the aerial terminals of the interfering receiver at any frequency in Band IV or V and the voltage produced at the aerial terminals of the 'interfered with' receiver as a result of coupling between the aerials is assumed to be 50 dB[1]. This applies to two aerials disposed in a manner typical of adjacent semi-detached or terrace houses.

2.2. Direct Radiation from Interfering Receiver

The permitted limit for receiver radiation is specified in B.S.905 in terms of the field strength produced at a distance of 3 m. In an average domestic situation in adjoining semi-detached or terrace houses, two television receivers may be operating either side of the party wall and spaced by about 1·5 m. It will be assumed that the interference field strength varies inversely with distance and that the wall attenuation is 6 dB. From these assumptions it follows that the interference field strength at the 'interfered with' receiver is equal to that measured at 3 m from the interfering receiver on an unobstructed site.

2.3. Receiving Aerial and Feeder Installation

For the wanted signal it is assumed that the u.h.f. receiving aerial and feeder will produce a voltage of x–17 dB(μV) across the input terminals of the receiver from a field strength of x dB(μV/m).* This is based on an aerial with a forward gain of 10 dB relative to a half-wave dipole, a feeder loss of 4 dB and a signal frequency of 650 MHz, i.e. at approximately the mid-band frequency of the u.h.f. band.

2.4. B.S.905:1969 Limit for R.F. Voltages appearing at the Receiver Aerial Terminals

Provided that the receiver has a nominal vision carrier i.f. of 39·5 MHz with the frequency of the local-oscillator above that of the signal and that the possible detuning of the receiver is restricted to −2 MHz + 0·6 MHz, the maximum permitted level at the fundamental oscillator frequency is 60 dB(μV), measured across a 75 ohm resistor at the aerial terminals. If these conditions are not met, the limit is 46 dB(μV).

Since all British-made receivers of recent or current manufacture have a 39·5 MHz i.f. for the 625-line system and local oscillator high, manufacturers will doubtless regard the relaxed limit of 60 dB(μV) as applicable. The requirement for restricted detuning states 'the amount of detuning is limited ...... either by some positive means or by resulting in unacceptable picture and/or sound degradation.' There are obvious difficulties in deciding at what point a degradation becomes unacceptable.

2.5. B.S.905:1969 Limit on Local-Oscillator Radiation

With the same conditions governing the i.f. and detuning as in Section 2.4 above, the limit for the radiated field 3 m from the receiver is 70 dB(μV/m). If the restrictive conditions are not met, the limit is 56 dB(μV/m). As discussed in Section 2.4, manufacturers will undoubtedly work to the relaxed limit of 70 dB(μV/m).

2.6. B.S.905:1969 Limit on Immunity

Immunity refers to the sensitivity of the receiver to direct pick-up of unwanted signals at the tuned frequency. It is defined as the ratio a/b where

> a is the field strength [in the vicinity of the receiver chassis] required to produce a given output from the receiver when it is connected to a length of terminated feeder, and
>
> b is the field strength required at a half-wave dipole connected to the same receiver via the same feeder [assumed lossless for this purpose] to produce the same output, when the receiver and feeder are placed in a perfectly screened enclosure.

The limits that should be equalled or exceeded are given in B.S.905 as:—

470 MHz to 582 MHz (Band IV) : 30 dB
614 MHz to 960 MHz (Band V) : 25 dB

Since the lower limit of 25 dB applies over the greater part of the u.h.f. band, the more stringent figure for Band IV will be disregarded for the purpose of calculating interference levels in this report.

Calculating on the basis of the mid-band frequency of 650 MHz, as in Section 2.3, the immunity figure of 25 dB can be expressed as a ratio between interference field strength and equivalent input voltage to the receiver as follows:—

> a field strength of x_i dB(μV/m) in the vicinity of the receiver is equivalent to a voltage at the aerial-input terminals of the receiver of $x_i - 48$ dB (μV).

3. SIGNAL-TO-INTERFERENCE RATIOS

The signal-to-interference ratios calculated in this Section apply to situations in which the interfering and 'interfered with' receivers are in adjacent semi-detached or terrace houses, the wanted-signal field strength is at the nominal level defining the service area limit, 70 dB(μV/m), and both receivers just comply with B.S.905 limits.

3.1. Interference arising from Aerial-to-aerial Coupling

Interference voltage at aerial terminals of interfering receiver (from 2.4)	60 dB(μV)
Interference voltage at aerial terminals of 'interfered-with' receiver (from 2.1)	10 dB(μV)
Wanted signal voltage at input of 'interfered-with' receiver (from 2.3)	53 dB(μV)

Signal-to-interference ratio ...... 43 dB

3.2. Interference arising from direct Receiver-to-receiver Coupling

Interference field at 'interfered-with' receiver (from 2.2 and 2.5)	70 dB(μV/m)
Equivalent interference voltage at input terminals of 'interfered-with' receiver (from 2.6)	22 dB(μV)
Wanted-signal voltage at input of 'interfered-with' receiver (from 2.3), assuming a wanted field strength of 70 dB(μV/m) at the aerial	53 dB(μV)

Signal-to-interference ratio ...... 31 dB

In B.S.905, the limits from which this result has been calculated (those for radiated interference and for immunity) are each specified as the worst figures obtained for a receiver at any frequency in the band

---

* Throughout this report, r.f. voltage levels for both signal and interference are given in terms of the terminated voltage across a 75 ohm load.

and in any direction from the receiver; it is therefore justifiable to apply a diversity factor to the calculated result because values near the limit are very unlikely to occur simultaneously for each receiver in the direction of the other. There is little information available on which to base an estimate of the value of this diversity factor but 10 dB is regarded as a reasonable estimate. Taking this into account, we have a signal-to-interference ratio for receiver-to-receiver coupling of 41 dB.

4. PROTECTION RATIO REQUIRED AGAINST C.W. INTERFERENCE

There are no generally-agreed protection ratio data for the PAL system on Standard I, the colour system used in the U.K. However, the CCIR publish a protection ratio curve for the 625-line NTSC system on Standard I covering frequency differences up to about 5·7 MHz[3] and for a monochrome system on Standard I covering frequencies up to 6·5 MHz[4]. These curves are stated to represent the protection ratios '...... acceptable .... for a small percentage of the time, not precisely defined, but assumed to be between 1% and 10%' and this is generally accepted as corresponding to a grading of 3·5 on the EBU six-grade impairment scale.[5]

Fig. 1 gives curves of the protection ratios required by the PAL system, Standard I, against C.W. interference at frequencies between 4 MHz and 6·5 MHz above that of the vision carrier. The curve for grade 3·5 has been constructed by combining the NTSC curve from reference 3 with the portion of the monochrome curve from reference 4 covering the frequency range above about 5·5 MHz. The curve for grade 1·5 was obtained from the grade 3·5 curve by increasing the protection ratio by 12 dB, i.e. 6 dB per grade, between 4 MHz and 5·6 MHz and by from 5 dB to 7 dB between 5·6 MHz and 6·5 MHz. The allowance of 6 dB per grade over the lower part of the range is in accordance with currently-accepted practice. The smaller allowance in the region of 6 MHz is based on measurements made by BBC Research Department.[6]

It must be emphasized that the applicability of the curves of Fig. 1 to the PAL system has not been verified by experiment and the curves have no recognized status. They are put forward here as a basis for the assessment of interference in default of any other information.

The protection ratios of Fig. 1 refer primarily to colour reception of a colour transmission. There is evidence that the protection required for monochrome reception of a colour transmission is sensibly the same if the receiver has the full bandwidth required by the system and is accurately tuned.[1] If the response of an 'interfered with' monochrome receiver to the higher video modulation frequencies is reduced, either by inadequate bandwidth or by mistuning, its susceptibility to 'n to n + 4' interference will also be reduced at the expense of some loss of picture resolution. However, since it would be inadvisable to assess the severity of this type of interference in the future on the assumption that viewers will tolerate avoidable picture degradation, the protection ratios shown can be taken as applicable to either colour or monochrome reception of a colour transmission.

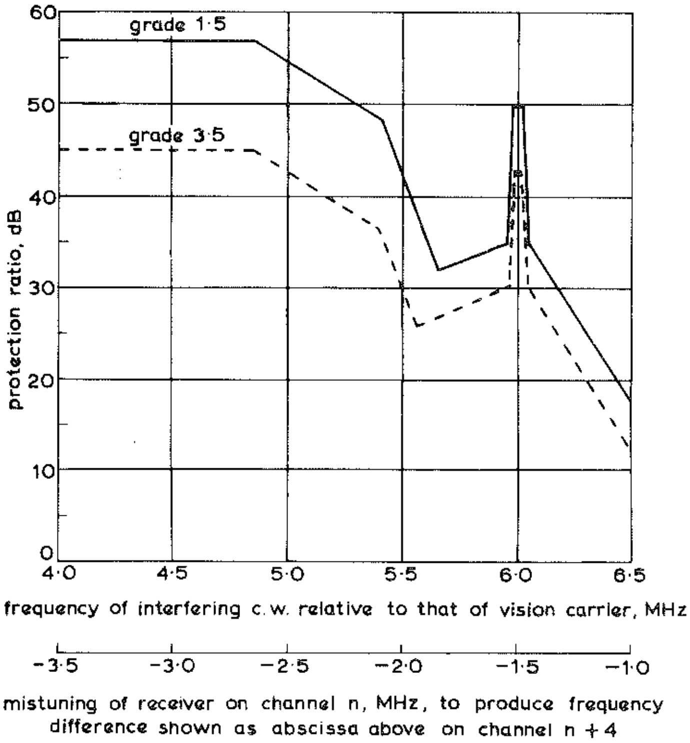

Fig. 1 - Protection ratio required by PAL, Standard I, colour television signal against c.w. interference (Tentative curves)

5. DISCUSSION

Applying the signal-to-interference ratios calculated in Sections 3.1 and 3.2, viz. 43 dB and 41 dB, to the curves of Fig. 1, it is apparent that the subjective grading of the interference produced depends on the amount of mistuning of the interfering receiver. It is unlikely on statistical grounds that interference falling within the narrow band embraced by the sharp ± 20 kHz peak centred on 6 MHz will occur often or, in view of the drift of u.h.f. local oscillators, will persist for long periods. If we disregard this peak it appears that the interfering receiver must be mistuned by the maximum amount permitted by the B.S.905 limit, i.e. 2 MHz, for any visible interference to be produced. Even with this maximum mistuning the interference will be grade 1·5, i.e. assessed as 'just perceptible' by 50% and 'imperceptible' by 50% of viewers.

It is pertinent at this point to examine the assumptions on which this conclusion is based in order to estimate what proportion of viewers are likely to suffer worse interference than that calculated.

(i) Wanted-signal field strength

A wanted-signal field strength of 70 dB(μV/m) has been assumed. When the u.h.f. plan is fully implemented, between 1·5% and 2·0% of the population will receive a lower field strength than this.

(ii) Performance of receivers

B.S.905 is based on compliance with the limits by 80% of receiver production. Bearing in mind that receivers are mass-produced, which implies a high degree of uniformity between units, it is unlikely that if 80% of production is within limits the remaining 20% will be far outside them.

(iii) Coupling between receivers or aerials

The disposition of the two receivers upon which the amount of direct coupling was calculated is explained in Section 2.2. The figures for aerial coupling are typical of a case where the two aerials are spaced by 0·9 m at right angles to their line of shoot or 2·7 m along it. It is considered that the coupling assumed could be achieved in any domestic installations without undue difficulty, although this might entail moving one or both aerials or receivers.

(iv) Signal frequency

Calculations involving the signal frequency have all been made for 650 MHz. This will produce an error of some 3 dB at the upper and lower ends of the u.h.f. band. This is not regarded as serious.

(v) Mistuning of interfering receiver

Colour receivers operating on a colour transmission are most unlikely to cause n to n + 4 interference since the degree of mistuning required would result in a complete loss of the colour information.

With monochrome receivers, downwards mistuning produces a progressive loss of picture resolution and ultimately a degradation or total loss of the sound signal. There is therefore some incentive for the viewer to tune his receiver with reasonable accuracy and, with the increasing use of push-button tuners, this accuracy may become easier for the unskilled to achieve.

6. CONCLUSIONS

Provided that receivers comply with British Standard interference limits, interference from a receiver on channel n to another on channel n + 4 should not present a serious problem. It will not generally produce interference graded worse than 1·5 except where there is a combination of adverse circumstances, e.g. a wanted signal field strength below 70 dB(μV/m) together with either a neighbouring receiver detuned to the maximum extent or an unusually high degree of coupling between adjacent installations. Even in such difficult cases, co-operation between neighbours or some re-positioning of aerials or receivers should reduce the trouble to negligible proportions.

7. REFERENCES

1. Local-oscillator interference with u.h.f. television reception. BBC Research Department Report No. G-093, Serial No. 1964/32.
2. British Standard 905:1969. Specification for radio interference limits and measurements for television and v.h.f. sound receivers.
3. C.C.I.R. Documents of the XIth Plenary Assembly, Oslo 1966, Vol. V, Report 306, Fig. 1, p.214.
4. Ibid, Recommendation 418-1, Fig. 5, p.58.
5. Ibid, Report 405, Note 2, p.250.
6. C.W. interference with monochrome u.h.f. television reception. BBC Research Department Report No. G-099, Serial No. 1966/7.

JMP/EP

Printed by BBC Research Department, Kingswood Warren, Tadworth, Surrey